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Study on Exchange of Radioactive Bromide Ion on Duolite A-162 Resin

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The kinetics of ion exchange reaction has been studied by application of ^{82}Br as tracer isotope. The exchange rates of ion exchange resin Duolite A-162 have been determined. Kinetics of ion exchange at different temperatures ranging from 27 to 50°C and particularly at low concentration of electrolyte (KBr) ranging from 0.005 to 0.100 M and for different amount of ion exchange resin ranging from 1 to 5 g is carried out.

Key words: Duolite A-162, ^{82}Br tracer isotope, Ion exchange resin.

Ion exchange resins have many applications in scientific research[1,2] and industries[3] due to their mechanical, thermal and exchange properties. The property of ion exchange resin to exchange one type of ion with another and the extent to which the resin can replace its ions with the other ions depends upon the nature of ion to be exchanged, capacity, concentration and temperature.

In recent years development in ion exchange technique is tremendous and number of ion exchange resins have been synthesized to meet the ever-growing needs of industries. Regarding the utilization of ion exchange resins for industrial purpose first attempt was made by Grans for softening of water and also for decolorising sugar solution. Himsley and McArrey conducted a review of ion exchange resins and their advantages in waste water treatment. The efficient operation of ion exchange resin even at high flow rate is one of the five features of this material. Therefore a knowledge of factors like temperature, concentration of electrolyte and amount of ion exchange resin which largely influence the rate of ion exchange is of great importance for the effective use of ion exchangers in chemical industries.

The resin used (Duolite A-162) was supplied by Auchtel India Ltd, Ratnagiri. Duolite A-162 which is a strongly basic anion exchanger in chloride form was converted into bromide form using 10% KBr solution, in a conditioning column. The conditioned resins were then air dried and used for further study. For this study ^{82}Br was effectively used as tracer isotope which was obtained from Board of Radiation and Isotope Technology (BRIT), Mumbai. KBr solutions of different concentration were prepared and by using diluted ^{82}Br solution these solutions of different concentrations were labelled, such that 1.0 cm^3 of this labelled solution will have known initial activity 10,000 to 15,000 counts per minute as measured on γ-ray spectrometer. To these solutions of different concentrations of known initial activity (cpm), fixed amounts of ion exchange resin (1.0 g) in bromide form are added and under continuous stirring of solution the activity of 1.0 cm^3 solution is measured at an interval of every 2 min. Due to rapid exchange of radioactive bromide ions in solution with bromide ions on ion exchange resins, activity of 1.0 cm^3 solution decreases rapidly for initial interval of time but after sometime it decreases slowly. The decrease in activity (cpm) will correspond to the activity on the resin surface. This experiment is similarly repeated for different temperatures ranging from 27 to 50°C. The temperature of solution is maintained using insurf water bath. Similarly the experiment was repeated by varying amounts of ion exchange resin from 1.0 g to 5.0 g for fixed temperature of 27°C and for fixed concentration of bromide ion solution (0.005 M).

Due to increase in temperature of KBr solution the collision between the radioactive bromide ions in solution and bromide ions on ion exchanger increases and hence the reaction rates of rapid exchange process are observed to increase with rise in temperature (Table-1), but the increase in reaction rate with increase in amount of ion exchange resin[4-9] is more pronounced which is due to increase in number of exchangeable bromide ions on ion exchange resin (Table-2). From the reaction rate calculated at various temperatures, the activation energy for ion exchange reaction in KJ/mole is calculated by Arrhenius equation. It was observed that as the concentration of bromide ion in solution increases the number of effective collisions between the reactants increases and hence the energy of activation decreases (Table-3). The amounts of bromide ion exchanged in millimoles when calculated for different concentrations of bromide ion solution were observed to increase with increase in concentration of bromide ion solution. This increase takes place for fixed temperature, fixed amount of ion exchange resin and for specific reaction rate which also remains constant. The amount of bromide ion exchanged in millimoles increases efficiently with increase in amount of ion exchange resin.

TABLE-1
EFFECT OF TEMPERATURE ON ION EXCHANGE REACTION

Concentration of KBr solution = 0.005 M
Amount of ion exchange resin = 1.0 g

Temperature (°C)	27.0	35.0	40.0	45.0	50.0
Reaction rates (min^{-1})	0.126	0.161	0.172	0.184	0.199

TABLE-2
EFFECT OF AMOUNT OF ION EXCHANGE RESIN ON ION EXCHANGE REACTION RATE

Concentration of KBr solution = 0.005 M

Temperature = 27°C

Amount of ion exchange resin (g)	1.0	2.0	3.0	4.0	5.0
Reaction rate (min^{-1})	0.126	0.151	0.160	0.180	0.195

TABLE-3
EFFECT OF CONCENTRATION OF BROMIDE ION SOLUTION ON ENERGY OF ACTIVATION OF ION EXCHANGE REACTION

Amount of ion exchange resin = 1.0 g

Concentration of bromide ion solution	0.005	0.010	0.020	0.040	0.100
Energy of activation (KJ/moles)	6.120	5.929	5.872	5.738	5.547

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